# Analysis of Orthorectification Accuracy of Pleiades and SPOT6 Images For Mapping Basic of RDTR Coastal Area (Case Study: District of Jenu, Tuban)

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**Abstract**. The coastal area of Tuban Regency in various spatial plans is planned to be one of the economic growth centers in East Java. The plan requires a detailed Spatial Plan (RDTR) map, especially the Coastal Area with high accuracy. However, the current RDTR map still lacks high accuracy. Therefore, the purpose of this research is to analyze the accuracy of high-resolution satellite image orthorectification, so that it can be used for making RDTR base map. In this research, orthorectification process is done by using satellite image data of Pleiades 1A and SPOT6 with Rational Polynomial Coefficient (RPC) method. As a supporting data are Ground Control Point (GCP) of 11 points and Independent Check Point (ICP) of 12 points and DEM Astrium Terra SAR-X data for satellite image altitude correction so that the image is upright. Based on the processing and data analysis, the accuracy horizontal image of Upright Pleiades 1A is 0.25 meters and the SPOT6 Upright image is 1.8 meters. Based on the horizontal accuracy value, the satellite images of Pleiades 1A and SPOT6 meet the horizontal accuracy standard of the base map scale of 1: 5000 and 1: 10,000 in accordance with Perka BIG No. 15 the year 2014. In addition, this research also conducted the perturbation of TSS of Pleiades 1A satellite image and SPOT6 using Laili algorithm 2015. From the result of image processing and ground truth data can be said that TSS concentration is low ($<100$ mg / l) according to Permen LH Number 01 of 2010. Thus can be said that marine waters in District of Jenu classified as clean and it does not affect shoreline changes. The result of correlation test of image TSS of Pleiades 1A and SPOT6 with ground truth data is very strong while image data of Pleiades 1A and SPOT6 with aerial photography data have low and very low correlation coefficient.

**Keywords**: Orthorectification, Pleiades 1A, SPOT6, TSS, Coastal Areas

## 1.Introduction

Tuban is one of the cities in the northern coastal area of Java Island which has 65 km long coastline and 22.608 km2 of sea area stretching from the east of Palang Subdistrict to the west of Bulu Bancar District[1]. Along the coast of Tuban Regency, there are many infrastructures and activity centers, including the main arterial road Pantura connecting East Java - West Java, ports, warehousing, industry, settlements, and tourism. The coastal area is planned as an integrated industrial area of East

Java with the development plan of the port, the development of fisheries and municipalities, as well as the construction of minapolitan areas[2].

As an economic and activity center, the coastal area of Tuban Regency should have good spatial use planning and in accordance with prevailing laws and regulations. Therefore, in order to avoid confusion that can cause damage to environment and ecosystem, hence needed detail map of spatial (RDTR) especially coastal area which has high accuracy. Today, however, many RDTR maps do not yet have high accuracy in accordance with the rules of the Perka BIG[3].

In making the RDTR map a high-resolution satellite image is required that has a wide coverage and can describe the physical appearance in accordance with the appearance in the field, thus providing accurate information. As is known that in the process of satellite image recording there are some error factors caused by shifts and slope and topographic variations that make coordinate information and image altitude not in accordance with the real situation. Therefore, orthorectification process is needed to reduce the various distortions caused by camera/sensor tilt and relief shift[4].

In addition to the orthorectification process also needs to be done accurate analysis orthorectification image of Pleiades and SPOT6 on field conditions. So research is needed to know the accuracy of orthorectification image of Pleiades and SPOT6 for Tuban Regency especially Jenu Subdistrict which have quite rapid development[2]. Therefore, in this final project, the authors will analyze the accuracy of orthorectification images of Pleiades and SPOT6 to give a recommendation for making the basic map of coastal area 1: 5000 and 1: 10,000 RDTR which refers to Tentang Pedoman Teknis Ketelitian Peta Dasar,2014[2].

## 2. Research Methodology

### 2.1 Location

Location of research in this final project is in District Jenu, exactly 10 km west of Tuban with an area of 81.62 km2. Geographically located at 6° 49'16 "LS - 111° 53'27" BT to 6° 53'10 "LS - 112° 3'2" BT. The administrative boundary is adjacent to the Java Sea in the north, Regency of Tuban in the east, Merakurak District in the south and Regency of Tambakboyo in the west.
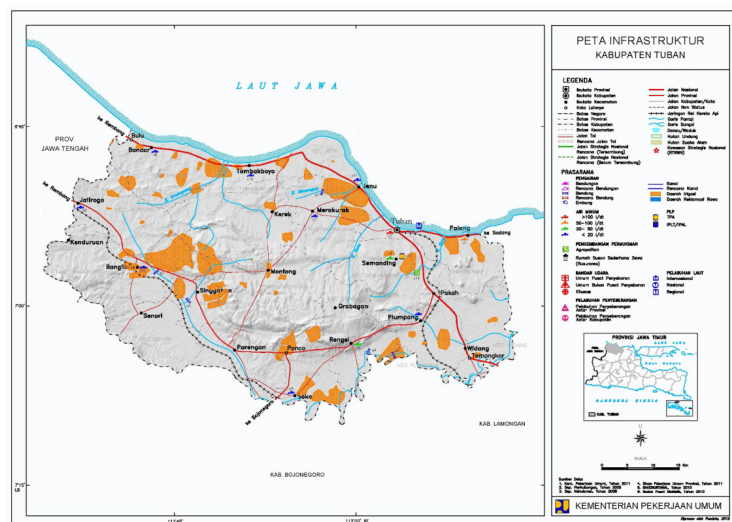


**Figure 1.** Location (Source: PU Tuban)

### 2.2 Data and Equipment

*2.2.1 Data.* (a) Satellite images of Pleiades 1A 2015; (b) Satellite images of SPOT6 2015; (c) DEM Astrium Terra SAR-X; (d) Map of Rupa Bumi Indonesia (RBI) 1:25000; (e) Aerial photo; and (f) Coordinate of GCP and ICP points from GPS measurement results

*2.2.2 Equipment.* Hardware: Geodetic GPS, Stative dan *tribrach*, Tape measure, Phantom 3 advance camera, Laptop, Stationery and survey form. Software : *Microsoft Office,* Satellite image processing software, Orthorectification processing software, Data processing software, *and* GPS data processing software

*2.3 Flowchart of Data Processing*

Stages of data processing in this research are as follows:

1. The data used in this final project are Pleiades 1A and SPOT6 satellite images, Astra Terra SAR-X DEM, GCP coordinate point data and ICP, RBI map 1: 25.000, aerial photo of the coastal area and sample test of TSS.
2. Pansharpening is done to obtain a high scope by combining multispectral and panchromatic channels.
3. Cropping area using RBI map 1: 25000 according to the condition of case study area of District of Jenu, Tuban.
4. The design of the net is made based on the points that have been obtained by connecting the point into a net and then calculated SoF $\leq$ 1.
5. Interpolate GCP to find coordinates of approaches that will be used for field measurement. GCP data from field measurements will be used in orthorectification processes previously processed using GPS software.
6. The process of orthorectification using Astrium DEM data and GCP coordinates obtained from field measurements using GPS. The orthorectification method used is the Rational Polynomial Coefficient (RPC) method with the tolerance value of RMSE $\leq$1.5 pixel [5].
7. The orthorectification result is an upright image of Pleiades 1A and SPOT6.
8. The ICP interpolation process is used to determine the coordinates of the approach to be used during field measurements. After field ICP measurements obtained field coordinates of ICP previously processed using GPS data processing software and will be used for the process of precision test.
9. The result of orthorectification is done by the accuracy test process using the coordinate of ICP point that has been measured in the field, where the accuracy test refers to Peraturan Kepala BIG Tentang Ketelitian Peta Dasar and Modul Validasi Peta Rencana Tata Ruang [3].
10. Satellite imagery TSS calculations using Laili algorithm, 2015 [6].

$$TSS = 31.42 * ( g\rho RED / \log \rho NIR) – 12.719 \text{ (mg/l)} \qquad (1)$$

As the supporting data of the analysis of coastline change, then validate TSS field data from coastal air capture area and TSS sample test. The TSS sampling is done as below:
    a. Prepare bottles that have been covered with Duct tape, this is done for Reduce sun exposure directly.
    b. Bottle to be weighed for Used at a certain depth.
    c. Take a water sample (TSS) at that location has been determined.
    d. Label the bottle, not to be confused With another location.
    e. Then tested the TSS sample at Tuban DLH laboratory for getting TSS concentration value.
11. The result of TSS image calculation and TSS field validation data is done a correlation to know the relationship between the two data. The TSS consumption data is used to support an analysis of possible shoreline changes.
12. In the process of analysis, there are two data that is done analysis that is the result of horizontal accuracy test and result of correlation of TSS image and field data. Where the results of value TSS used as supporting data analysis of coastline changes.
13. The definitive map in question is a recommendation map for the RDTR basic map of the coastal area of Jenu District, Tuban 1: 5000 scale for Pleiades 1A and 1: 10,000 images for SPOT6 images.

## 3. Result and Analysis

*3.1 Design and Strength of Figure*

Determining the position of the ground control point (GCP) for geometric correction is required for the planning and calculation of the strength of the net (Strength of Figure (SoF). The smaller the net power factor number, the better the net configuration is concerned, and otherwisw[7]. The shape of the design of the net that has been formed can be seen in Figure 2.
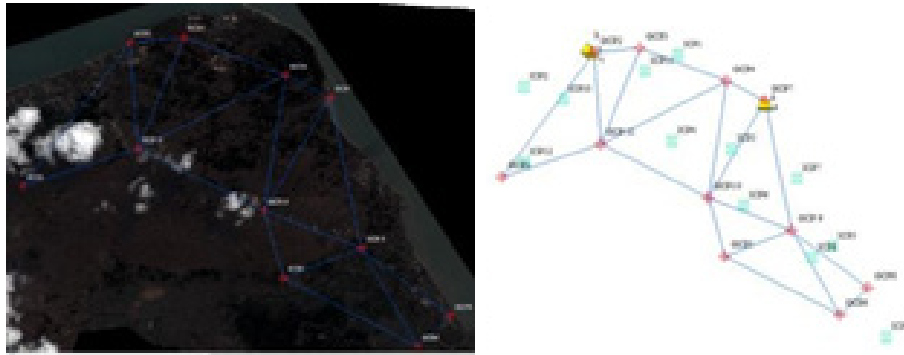


**Figure 2.** Design of Ground Control Point

To see the strength of the net formed, then calculated the strength of the net using the formula as follows:

Number of baselines: 31 Number of dots: 11

$N\_$ size: $\Sigma$ baseline x 3 = 93 $N\_$ parameter: $\Sigma$point x 3 = 33

U: ($N\_$ size) - ($N\_$parameter) = 60

SOF = 0.216

From the results of these calculations, it can be said that the design of the nets made has met the tolerance and considered strong[6].

*3.2 Coordinates of Ground Control Point*

Measurement of the ground control point in this study using GPS Geodetic with a static differential method using 3 GPS with duration of measurement ± 60 minutes. The measurement results are processed using GPS processing software including post-processing process (baseline processing) and network adjustment.

The GCP coordinates are tied to the coordinates of CORS ITSS and SRGI in the Tuban region, with SRGI coordinate difference measurements and SRGI BIG as follows dx = -4.306 meters dy = 0.391 meters. So obtained GCP coordinates as follows:

**Table 1.** Coordinates of Ground Control Point

| Point ID | Coordinate GCP | |
|---|---|---|
| | X (m) | Y(m) |
| GCP 01 | 600491.450 | 9246507.632 |
| GCP 02 | 603117.845 | 9251281.283 |
| GCP 03 | 604623.091 | 9251459.875 |
| GCP 04 | 607571.479 | 9250219.753 |
| GCP 05 | 608088.481 | 9243562.887 |
| GCP 06 | 612050.928 | 9241354.470 |
| GCP 07 | 608909.184 | 9249528.496 |
| GCP 08 | 612881.915 | 9242403.060 |

| | | |
|---|---|---|
| GCP 09 | 610201.187 | 9244564.668 |
| GCP 10 | 607356.837 | 9245760.250 |
| GCP 11 | 603632.382 | 9247795.181 |

*3.3 Orthorectification*

In this final project, orthorectification process is done using Rational Polynomial Coefficient (RPC) method. In the orthorectification process using data 11 coordinates GCP point and DEM Astrium Terra SAR-X as a height correction processed with orthorectification processing software so that obtained RMSE value.

From the result of orthorectification processing, the RMSE image of Pleiades 1A is 0.108 meters with details in Table 2. Where the RMSE values of both images have fulfilled the tolerance set by Perka BIG 2014[3].

**Table 2.** RMSE of Pleiades IA Image Orthorectification

| Point ID | | | RMSE |
|---|---|---|---|
| | X (m) | Y(m) | (m) |
| GCP 01 | 600491.450 | 9246507.632 | 0.08 |
| GCP 02 | 603117.845 | 9251281.283 | 0.04 |
| GCP 03 | 604623.091 | 9251459.875 | 0.01 |
| GCP 04 | 607571.479 | 9250219.753 | 0.04 |
| GCP 05 | 608088.481 | 9243562.887 | 0.18 |
| GCP 06 | 612050.928 | 9241354.470 | 0.21 |
| GCP 07 | 608909.184 | 9249528.496 | 0.11 |
| GCP 08 | 612881.915 | 9242403.060 | 0.16 |
| GCP 09 | 610201.187 | 9244564.668 | 0.13 |
| GCP 10 | 607356.837 | 9245760.250 | 0.11 |
| GCP11 | 603632.382 | 9247795.181 | 0.1 |
| | | RMSE | 0.108 |

While the value of the RMSE SPOT6 image of 0.642 meters with details in Table 3.

**Table 3.** RMSE of Pleiades IA Image Orthorectification

| Point ID | Coordinate of GCP SPOT6 | | RMSE (m) |
|---|---|---|---|
| | **X (m)** | **Y(m)** | |
| GCP 01 | 600491.450 | 9246507.632 | 0,021527778 |
| GCP 02 | 603117.845 | 9251281.283 | 0,024305556 |
| GCP 03 | 604623.091 | 9251459.875 | 0,027083333 |
| GCP 04 | 607571.479 | 9250219.753 | 0,024305556 |
| GCP 05 | 608088.481 | 9243562.887 | 0,06875 |
| GCP 06 | 612050.928 | 9241354.470 | 0,040277778 |
| GCP 07 | 608909.184 | 9249528.496 | 0,059027778 |
| GCP 08 | 612881.915 | 9242403.060 | 0,024305556 |
| GCP 09 | 610201.187 | 9244564.668 | 0,022916667 |
| GCP 10 | 607356.837 | 9245760.250 | 0,025694444 |
| GCP 11 | 603632.382 | 9247795.181 | 0,09375 |
| **RMSE** | | | **0,44583333** |

*3.4 Test of Accuracy*
In this research, there are 12 points of accuracy using ICP point according to Modul Validasi Peta Rencana Tata Ruang[4]. The distribution of ICP points can be seen in Figure 3.
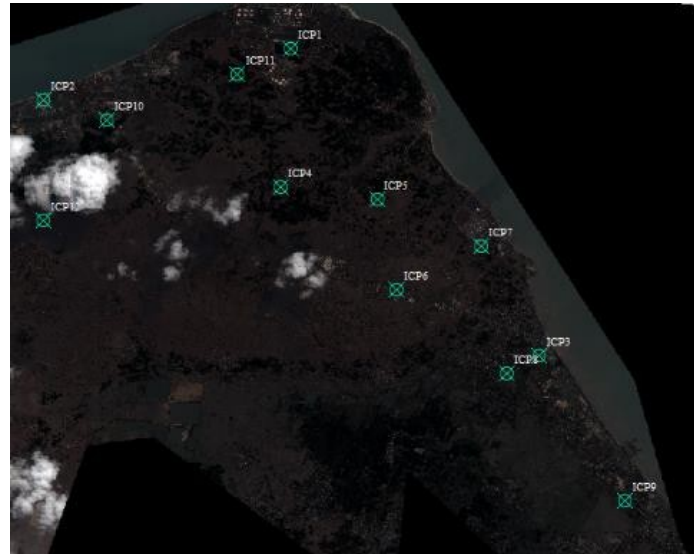


**Figure 3.** Distribution of ICP

The measurement of ICP point using Geodetic GPS and the method that used is rapid static with duration ± 15 minutes. The measurement result is processed using GPS processing software including post-processing process (baseline processing) and network adjustment.

These ICP coordinates are tied to the coordinates of CORS ITSS and SRGI in the Tuban region, with SRGI coordinate difference measurements and SRGI BIG as follows:

dx = -4.306 meters dy = 0.391 meters

So we get the coordinates of ICP as follows:

**Table 4.** Coordinate of ICP

| Point | Coordinate ICP | |
|---|---|---|
| | X (m) | Y(m) |
| ICP 01 | 605904.661 | 9251229.177 |
| ICP 02 | 600895.765 | 9249945.277 |
| ICP 03 | 611581.194 | 9243931.582 |
| ICP 04 | 605975.440 | 9247901.147 |
| ICP 05 | 607964.143 | 9247642.874 |
| ICP 06 | 608545.470 | 9245485.737 |
| ICP 07 | 610194.207 | 9246532.696 |
| ICP 08 | 610939.411 | 9243523.84 3 |
| ICP 09 | 613761.734 | 9240444.200 |
| ICP 10 | 602254.210 | 9249478.350 |
| ICP 11 | 604842.409 | 9250578.954 |
| ICP 12 | 601166.593 | 9247059.155 |

To know the accuracy of the result of orthorectification done the calculation of horizontal accuracy test using ICP point. And the value of RMSE ICP image of Pleiades 1A was 0,259 meters, with details in tables 5.

**Table 5**. RMSE of Pleiades

| Point ID | Coordinate ICP Pleiades 1A | | RMSE (m) |
| --- | --- | --- | --- |
| | X (m) | Y (m) | |
| ICP 01 | 605904.661 | 9251229.177 | 0.04 |
| ICP 02 | 600895.765 | 9249945.277 | 0.31 |
| ICP 03 | 611581.194 | 9243931.582 | 0.24 |
| ICP 04 | 605975.440 | 9247901.147 | 0.33 |
| ICP 05 | 607964.143 | 9247642.874 | 0.22 |
| ICP 06 | 608545.470 | 9245485.737 | 0.2 |
| ICP 07 | 610194.207 | 9246532.696 | 0.17 |
| ICP 08 | 610939.411 | 9243523.843 | 0.12 |
| ICP 09 | 613761.743 | 9240444.200 | 0.21 |
| ICP 10 | 602254.210 | 9249478.350 | 0.11 |
| ICP 11 | 6044842.409 | 9250578.954 | 0.05 |
| ICP 12 | 601166.593 | 9247059.155 | 0.03 |
| | RMSE | | 0.259 |

While the value of RMSE ICP SPOT6 image of 1,195 meters, with details in Table 6.

**Table 6.** RMSE of ICP SPOT6

| | X (m) | Y (m) | (m) |
| --- | --- | --- | --- |
| ICP 01 | 605904,661 | 9251229,177 | 1,18 |
| ICP 02 | 600895,765 | 9249945,277 | 2,8 |
| ICP 03 | 611581,194 | 9243931,582 | 2,4 |
| ICP 04 | 605975,44 | 9247901,147 | 2,51 |
| ICP 05 | 607964,143 | 9247642,874 | 1,3 |
| ICP 06 | 608545,47 | 9245485,737 | 0,22 |
| ICP 07 | 610194,207 | 9246532,696 | 0,3 |
| ICP 08 | 610939,411 | 9243523,84 3 | 1,06 |
| ICP 09 | 613761,734 | 9240444,2 | 0,36 |
| ICP 10 | 602254,21 | 9249478,35 | 0,31 |
| ICP 11 | 604842,409 | 9250578,954 | 0,38 |
| ICP 12 | 601166,593 | 9247059,155 | 1,41 |
| | **RMSE** | | **1,195** |

In this research, the value of RMSE 0.259 meter for Upright Pleiades 1A and 1.195 meters for an Upright image of SPOT6. Based on the results of calculation of accuracy test using ICP point from field measurement result according to the rules (Perka BIG, 2014)[7], obtained RMSE 0.3 meter for Pleiades 1A vertical image and RMSE 1.8 meter for SPOT 6 upright image.

*3.5 Accuracy Analysis*

From the result of horizontal accuracy test of an upright image of Pleiades 1A and SPOT6 can be seen in table 7.

**Table 7.** Accuracy Image and Verification Value of Pleiades 1A and SPOT 6

| Image Oerthorectificatified | Class 1 | | Class 2 | |
|---|---|---|---|---|
| | **H (m)** | **V (m)** | **H (m)** | **V (m)** |
| Pleiades 1A | 00.03 | - | - | - |
| SPOT6 | - | -- | - | - |

In accordance with Peraturan Kepala Badan Informasi Geospasial No. 15 of 2014 Tentang Pedoman Teknis Peta Dasar[7], calculation of horizontal accuracy of Upright image of Pleiades 1A and SPOT6. From the calculation of horizontal accuracy, the image value of Upright Pleiades 1A is 0.3 m, which means that the orthorectification result of the upright Pleiades 1A image is eligible and can be used for making RDTR base map of scale 1: 2,500 class 1 with 0.5m horizontal precision. While the image upright SPOT6 obtained horizontal accuracy of 1.8 m which means it has been eligible to be used for making a basic map of RDTR scale 1: 5000 class 3 with the condition of horizontal accuracy of 2.5 meters.

*3.6 Calculation of Total Suspended Solid*

In this research, the TSS of Pleiades 1A and SPOT6 satellite images use the algorithm from Laili 2015[5]. The TSS data is used as a supportive analysis of the possibility of shoreline changes. From the calculation, we get the TSS concentration as the detail in Table 8.

**Table 8.** Concentration Value of TSS on Pleiades 1A and SPOT 6

| Point ID | Definition | TSS Image of Pleiades 1A (mg/L) | TSS Image of SPOT6 (mg/L) |
|---|---|---|---|
| UJI 01 | 0 m from coastal | 17.109 | 12.701 |
| UJI 02 | 100 m from coastal | 24.066 | 26.121 |
| UJI 03 | 200 m from coastal | 20.729 | 22.123 |
| UJI 04 | 0 m from coastal | 24.737 | 21.03 |
| UJI 05 | 100 m coastal | 44.366 | 50.701 |

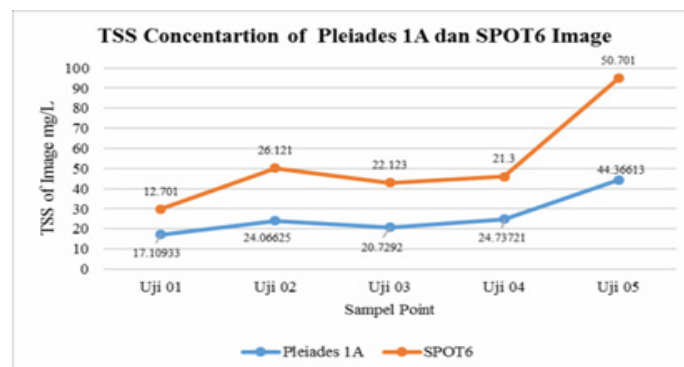From the above study then it is presented in graphical form as shown in figure 4.



**Figure 4.** TSS Concentration of Pleiades 1A and SPOT 6 Image

From the above graphic can be seen that at the test point 05 located ± 100 meters from the beach has the highest TSS concentration, it is because the location of test point 05 is not far from the factory and the existence of sea transportation activity. While the lowest TSS concentration is at the test point 01 located on the edge of the beach, it is due to the location of the test point 01 remote with residential areas and estuaries.

*3.7 Correlation Test of TSS Image and Groundtruth*
In this study also tested the correlation between image and ground TSS value (ground truth). Imagery data used are Pleiades 1A satellite images August 21, 2015, SPOT6 June 2015 and field data April 14, 2017 with details as in Table 9.

**Table 9** Concentration Value TSS Image of Pleiades 1A, SPOT6 and Ground Truth

| Point ID | Value of TSS Pleiades 1A mg/L | Value of TSS SPOT6 mg/L | Value of TSS Ground Truth mg/L |
|---|---|---|---|
| Uji 01 | 17.109 | 12.701 | 19.8 |
| Uji 02 | 24.066 | 26.121 | 23.4 |
| Uji 03 | 20.729 | 22.123 | 19 |
| Uji 04 | 24.737 | 21.3 | 26.3 |
| Uji 05 | 44.366 | 50.701 | 45.9 |

The concentration of TSS from image processing of Pleiades 1A and SPOT6 with the result of ground truth needs to be done correlation test. This is done to determine the suitability of the relationship between two variables that is the result of image processing and field measurement data, so it is necessary to calculate the correlation. Graph of image correlation result of Pleiades 1A and field can be seen in Figure 5.
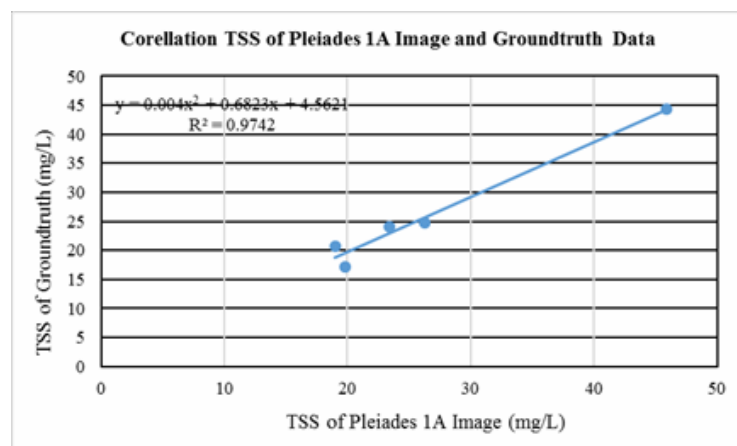


**Figure 5.** Correlation TSS Of Pleiades 1A and Groundtruth Data

While graph of the result of correlation calculation between SPOT 6 satellite image and field data can be seen in Figure 6.
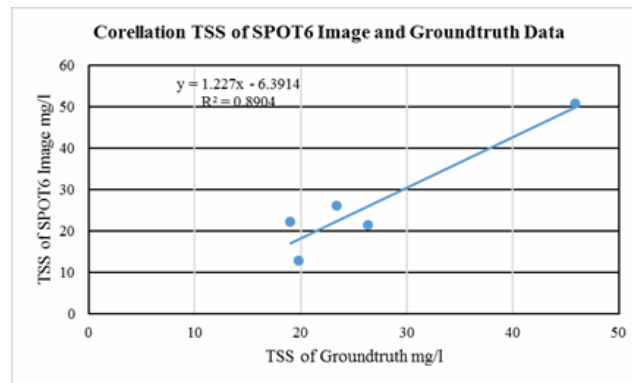
**Figure 6.** Correlation TSS Of SPOT6 and Groundtruth Data

The result of image correlation test of Pleiades 1A and field got correlation equal to (R) 0.98 whereas correlation test of SPOT6 and field got correlation equal to (R) 0.94. So it can be said that the correlation coefficient interpretation relation is very strong[8]. From the above calculations from both satellite imagery data and TSS ground truth data have low concentrations (<100 mg / l)[9]. So from the results of the waters of the District of Jenu classified as clean. It shows that TSS concentration does not have a big influence on the shoreline changes, especially in the marine waters of District Jenu. Because the researchers did not observe the tidal, so for the shoreline using interpretation image Pleiades 1A (09.54)[4].

*3.8 Correlation Test of TSS Image dan Aerial Photo*
In the research that has been done a correlation between the value of TSS Image and Air Photo, shown in Table 10.

**Table 10.** Concentration Value TSS Image of Pleiades 1A, SPOT6 and Aerial Photo

| Point ID | Value of TSS Pleiades 1A mg/L | Value of TSS SPOT6 mg/L | Value of TSS Aerial Phpto mg/L |
|---|---|---|---|
| Uji 01 | 17.109 | 12.701 | 18.701 |
| Uji 02 | 24.066 | 26.121 | 18.701 |
| Uji 03 | 20.729 | 22.123 | 12.719 |
| Uji 04 | 24.737 | 21.03 | 18.701 |
| Uji 05 | 44.366 | 50.701 | 18.701 |

The correlation test is conducted to find out the relationship between the two data. Graphs of image calculation results of Pleiades 1A and aerial photograph can be seen in Figure 7.
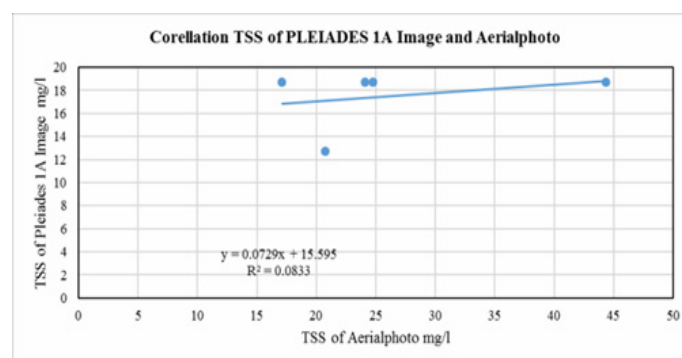


**Figure 7.** Graph of Correlation TSS Image Concentration Value of
Pleiades 1A and Aerial Photo

From the graph above it is known that the correlation value (R) 0.28 so that it can be said that the correlation between TSS image processing Pleiades 1A and aerial photographs are low[8]. While the SPOT6 TSS image correlation test and aerial photographs can be seen in Figure 8.
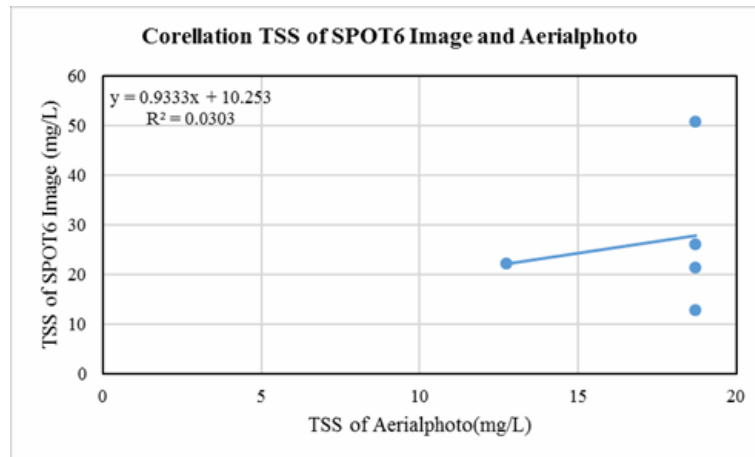


**Figure 8.** Graph of Correlation TSS Image Concentration
Value of SPOT6 and Aerial Photo

From the graph above it is known that the correlation value (R) 0.28 so that it can be said that the correlation between TSS image processing SPOT6 and aerial photographs are very low[8].

*3.9 Basic Map of RDTR District of Jenu, Tuban*
The result of base map of RDTR of the coastal area of District of Jenu Tuban can be seen in Figure 9.
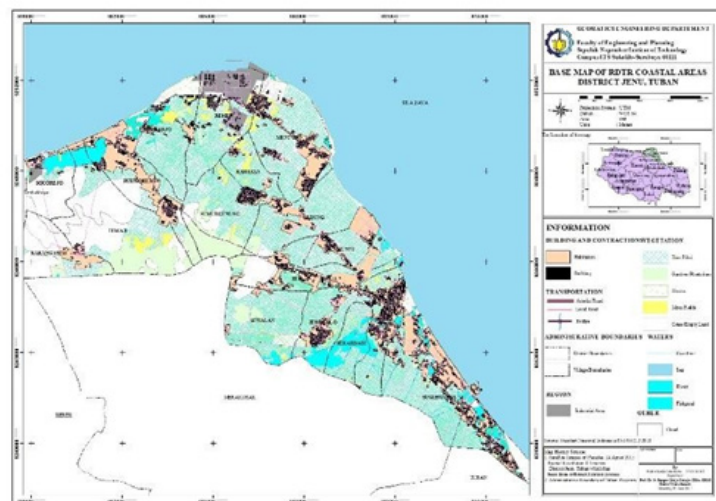


**Figure 9.** Base Map of RDTR Coastal Area of District Jenu, Tuban

The classification used under the rules of SNI RBI, 2010[10]. However, adjusted to the condition of the location of the case study that is District Jenu, Tuban.

**4. Conclusion and Recommendation**
Based on the results of the analysis that has been done in the previous discussion, it can be obtained conclusions from this study as follows:

1. In orthorectification process using 11 coordinate points of Control of Land (GCP), which got value RMSE image of Pleiades 1A 0.108 meter and SPOT6 0.642 image.

2. Based on Peraturan Kepala BIG No. 15 the year 2014[7], then the process of calculating the horizontal accuracy test using 12 coordinates of ICP point. With the horizontal accuracy of the image of Estuary Pleiades 1A 0.3 m, so the image of Estuary Pleiades 1A result of orthorectification is said to meet the requirement of RDTR base map of scale 1: 2,500 class 1. While SPOT6 has a horizontal accuracy of 1.8 m and qualified for RDTR 1 : 5000 class 3. The result will be recommended in making the base map of RDTR Coastal Area scale of 1: 5000 for the upright image of Pleiades 1A and 1: 10.000 Upright image SPOT 6.

3. The level of TSS concentration in the waters of the District of Jenu is low ie <100 mg / L[9]. So the low TSS concentration did not have a major effect on the shoreline changes in the District of Jenu. In the study of coastline, the determination is using an interpretation of the image of Pleiades 1A (09.54) which refers to Modul Validasi Peta Rencana Tata Ruang[4]. The correlation between ground truth data and image processing data of Pleiades 1A and SPOT6 is classified as very strong while correlation coefficient correlation data image of Pleiades 1A and SPOT6 and the aerial photograph is low and very low [8].

The suggestion given from the implementation of this research for subsequent research is to take the field data using aerial photographs should use aerial photographs that have a sensor Near Infra-Red (NIR) so that if processed using TSS algorithm produces a strong correlation between image TSS and TSS image processing air.

**Reference**

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